from vegetation; and (4) the evaporation from moist crystal deposits and from snow.

His conclusion follows:

In conclusion it is desired to emphasize two points, first, that the study of evaporation should not be confined to free-water surfaces but should be extended to capillary films surrounding soil grains, crystals of alkali salts and snow and in connection with soils should include the process of transpiration; second, that there is greatly needed a study of methods of measuring the various types of evaporation and an authoritative adoption of standards. The subject of evaporation is important not alone in western America but throughout all arid and semi arid regions of the world.

In view of the progress already made in the study of evaporation in its various phases in western America, it is suggested as appropriate and opportune at this time that a committee of the American Meteorological Society be appointed for the purpose of outlining needed investigation and selecting standard methods of observation.

THE COURSE TRAVELED BY WIND AND WEATHER IN A DAY—AN AID IN WEATHER FORECASTING[1]

551.515

By DR. C. KASSNER

[Berlin, Germany]

It is known from long experience that not only laymen but also many meteorologists overestimate the velocity of a weather change. In this I do not refer to the fact, for example, that after a rather long period of cold an approaching low-pressure area with warm winds on the front side does not bring a reversal of weather conditions by any means so rapidly as is expected by many who eagerly wish for it. This physical advance will not be considered here, but only the advance of the air masses with wind and weather, or, in other words, the problem of the location after 24 hours of a wind or a low pressure area that is advancing with a given velocity per second or per hour. In this it must naturally be assumed for the sake of simplicity that the path is a straight line. It will, indeed, be a matter of estimation only. But even so it appears to me that the solution of the problem will be rather useful, especially in bringing into lay circles clearer ideas as to the velocity of weather changes.

I proceed with a velocity of 10 meters per second—36 kilometers per hour, 864 kilometers per day of 24 hours. I have chosen this velocity (1) since from this estimation can be made readily for any other velocity, and (2) since this is on an average the velocity with which American depressions move across the Atlantic Ocean toward Europe. Much difficulty was encountered in the selection of the chart to include North America, the Atlantic Ocean, and Europe. I finally decided upon the Mercator projection. Further, in order to meet the requirements for Europe and America I chose two systems of isochronous lines; one with initial position in America, the other with corresponding position in Europe, namely, the meridians of 60° and 0° west longitude, which are marked 0–0. The European system has continuous lines, the American system broken lines. The numbers 1, 2, 3, etc., denote days, that is an air particle or a chosen part of a low pressure area after a day or 24 hours of advance along a parallel, thus from west to east or from east to west, will reach the isochron 1, and in two days the isochron 2, and so on. Of course the beginning may be made with any other isochron. The chosen system of drawing of lines and the different figures do not admit of exchange. We must always take only the lines of one system or those of the other, and not both indiscriminately.

[1] Translated from the German by C. Le Roy Meisinger.

The fact that the isochrons diverge toward the north is naturally the result of curvature of the earth and the projection of a sphere upon a plane surface.[2]

The following small tables may be of value in using the chart:

Velocity equivalents

Meters per second	Kilometers per hour	Kilometers per day
20	72	1,728
15	54	1,296
10	36	864
5	18	432
2.5	9	216

Distance traveled in 1 day in degrees of longitude

Latitude	Length (degrees longitude in kilometers)	Velocity in m. p. s. 20	15	10	5	2.5
°		°	°	°	°	°
70	38.18	45.3	33.9	22.6	11.3	5.7
60	55.79	31.0	23.2	15.5	7.7	3.9
50	71.69	24.1	18.1	12.1	6.0	3.0
40	85.38	20.2	15.2	10.1	5.1	2.5
30	96.47	17.9	13.4	9.0	4.5	2.2
20	104.63	16.5	12.4	8.3	4.1	2.1
10	109.63	15.8	11.8	7.9	4.0	2.0
0	111.31	15.5	11.6	7.8	3.9	1.9

Hence at latitude 70° a wind of 20 m. p. s. will traverse an entire quadrant in two days, but at the Equator it will traverse only one-third of that distance; at latitude 70° it would pass along the entire coast of North America, while at the Equator is would just cross South America. It is always useful in making such matters clear to give some geographical measurements, for example:

	Kilometers
Boston–Detroit	1,000
Buffalo–Key West	2,000
Chicago–Salt Lake City	2,000
Baltimore–Salt Lake City	3,000

Up to this point there has been considered only the movement in west-east or east-west direction; the charts contain, however, also the isochrons for the directions north-south and south-north, the broken lines parallel to the parallel circles. Here the velocity of 10 m. p. s. is taken as the basis and the lines are drawn to north and to south of the parallel of 50° N. latitude. In order to avoid confusing figures these lines are not numbered, and to me it appears unnecessary since there are only six to be considered.

If we wish to find with the aid of the chart after what length of time, on an average, a low pressure area whose center lies off Cape Hatteras will arrive on the European coast, we note that the continuous line 8 runs off Hatteras and so the minimum (pressure) is to be expected in the English Channel in about 8 days. An excellent example of this is the cyclone of August, 1873 (Hann, Lehrbuch der Meteorologie, 3 Aufl. S. 610, fig. 80), which lay off Hatteras on the 23d and off Ireland on the 31st; just 8 days were necessary for crossing the ocean. The storm of August 24–September 3, 1883, also shown in the figure mentioned, had a velocity twice

[2] Supervising Forecaster Bowie confirms the fact illustrated by Doctor Kassner's chart, viz, that the northern ends of the major axes of HIGHS and LOWS make greater distance in longitude than their southern ends, so that these major axes incline more and more from north-south to an east-west direction. This action is especially noticeable when troughs of low pressure and ridges of high pressure are about to pass eastward onto the Atlantic from the North American Continent. It is a phenomenon that all students of the weather chart should keep in mind.—*Editor*.

as great from August 28 to 29 (Chicago–Cape Hatteras) and a correspondingly rapid passage to the English coast in only 4 days.

Since weather reports and especially storm reports are now transmitted to ships by wireless my chart can serve in finding the approximate meeting place of ship and storm, especially since 10 m. p. s. is also the speed of many steamships.

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THE PHYSICAL AND GEOLOGICAL TRACES OF THE CYCLONE BELT ACROSS NORTH AMERICA[1]

By MARSDEN MANSON

[802 Hobart Building, San Francisco, Calif., December 5, 1924]

Whenever certain portions of the earth for long periods of time have been subjected to meteorological conditions differing from those imposed upon other areas, these different conditions set their marks. These marks, when correctly interpreted, yield lessons of wide import.

It is the object of this essay to show that the path of cyclonic activity of greatest frequency across the narrow continent of North America, from the wide Pacific to the Atlantic, has been subjected to maximum cyclonic activity along this belt, and that this action has persisted well back into geologic history. As the basis of this study, the tracks of LOWS as chartered by the United States Weather Bureau and published in the MONTHLY WEATHER REVIEW are used.

These tracks were studied for two periods, the first, for the 12 months beginning December 1, 1891, and ending November 30, 1892; the second, for the 12 months beginning December 1, 1921, and ending November 30, 1922.

In these studies each LOW which crossed the continent during these years was traced in distinguishing colors and lines from the UNITED STATES MONTHLY WEATHER REVIEW charts by seasons and by months.[2] From these the limits of the tracks of LOWS is outlined upon the accompanying chart; also the summit of the drainage into the Arctic Ocean, Hudson Bay, etc., and into the Gulfs of Mexico and California, etc.

It will be observed that the greater number of these storms move between quite well defined limits, although there are very wide divergent courses taken by some. The most important divergence is that which occurs seasonally on the Pacific coast as the sun moves to its solstitial positions, the summer course being more northerly than that of winter, and during the summer practically no rain falls near the coast south of parallel 42° N. These changes in the paths of LOWS approaching and crossing the coast line, thence into the interior of the continent, establish the wet and dry seasons of California and adjacent territory. Departures from this general winter course give abnormal seasonal precipitation in this State and a reversed abnormality north of this belt.

As the vertical sun approaches the equinoctial position over the Equator, some of the LOWS follow the winter and others the summer track, thus causing the spring and autumn rains of California to be lighter than those of winter, and fixing these seasons as wet or dry according to whether the greater number or intensity of LOWS follow the winter or summer course.

Counteracting pressures of anticyclonic areas.—Opposed to the lessening of pressure attending the passage of a LOW stands the increased pressure due to the passage of a HIGH. The surface of the earth, in isostatic equilibrium, is acted upon by these decreases and increases of pressure.[3] Doubtless the one should in a measure tend to counterbalance the other, if imposed upon the same areas and of equal force. But the Weather Bureau reports above referred to show that the paths of HIGHS are more widely different from those of LOWS. The HIGHS are not accompanied by the denuding effects of rain and snow, as are the LOWS. Hence the latter have unbalanced effects in their favor, and these must have their cumulative results as herein pointed out.

Now, if this great path of north temperate LOWS shall have remained fixed during the Modern Era, and indefinitely into the geologic past, distinctive physical and geologic traces must have resulted from this concentration of denuding activities.

In order to present the ultimate effects which the continued occurrence of a difference in barometric pressure is capable of producing, we must realize that over each square foot subjected to 1 inch less barometric pressure than another a relief of 70.5 pounds obtains. Upon a square mile this amounts to 877,000 tons; a difference of 1 inch is not unusual; indeed, this is not far from the average, and this lessening of pressure acts over areas several hundred miles in diameter. This action, with the accompanying denuding agencies, is repeated every few days now, and could not have been inoperative at any fixed period in geologic time, since one of its causes is the greater amount of solar energy absorbed by the air in the longer oblique path of solar radiation through it about latitude 50°.

This lessening of pressure is equivalent to a lifting force and may seem inconsiderable to the geologist accustomed to consider forces of vaster magnitude; but the great factor time being multiplied into the results gives them mass effects not at first realized. The results of the passage of a single cyclone are physically and geologically insignificant; those passing in a year might be recognized by careful measurements of sedimentations; those passing in several centuries could be so recorded that their results could be observed by successive generations; but when this factor time becomes lengthened into geologic units the effects become physically and geologically traceable.

Physical traces.—The parting of the waters draining into the Arctic Ocean and Hudson Bay, and into the Gulf of Mexico and the Atlantic Ocean, commences on the summit of the Rockies in about 49° N., thence eastwardly in a sinuous line to 75° E. longitude, thence northeastwardly to southwest Labrador in 57° N.

A section of the continent from the mouth of the Mississippi River to that of the Mackenzie crosses this divide near Winnipeg, and both of these great rivers rise on the summit of the great continental plateau.

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[1] The original studies of this subject were published in the *Transactions of the Technical Society of the Pacific Coast*, July, 1891, under the title, "Physical and Geological Traces of Permanent Cyclone Belts."

This subjects was extended to include the movement of cyclones across the Atlantic Ocean and the continent of Euro-Asia. The present paper is revised and rewritten from the above, and is restricted as indicated in the title.

In April, 1893, the author presented a paper to the Science Association of the University of California, entitled, "The Importance of North Pacific Weather Stations."

The colored maps of the earlier period of cyclone tracks across the continent issued in this paper are utilized herein. *See also Bulletin A*, U. S. Weather Bureau, H. H. C. Dunwoody, Washington, D. C., 1893. *Atlas of Meteorology, Plate 28*, Bartholomew, Edinburgh, Geographical Institute, 1899.

[2] In the tracks of cyclonic areas during the second period, or 30 years later than the first, a larger number of LOWS appear to have developed over the arid and semiarid regions of New Mexico, Arizona, California, and Mexico than in the former period. This is probably due to the establishment of a larger number of observing stations and more intensive studies of the data.

It is probable that the cyclones originating over this area are developments of the modern era of solar climatic control, which, in the views of the writer, did not prevail during geological climates. This subject can not be treated in this essay, but can be found in *The Evolution of Climates*, Manson, 1922.

[3] A convenient instrument for noting the approach and passage of areas of varying air pressures is the seismograph, and it is probable that properly placed seismographs would give warning of the approach of a LOW or of a HIGH prior to the barometer. The observations and researches of Mr. F. Napier Dennison, member of the American Meteorological Society, etc., are notable instances of original work in this field.